Journal of Agrometeorology 6 (1) : 131 -134 (Jun 2004)

Short communication

Water use efficiency of soybean (*Glycine max* L.) using line source sprinkler technique

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Water is often the primary limiting factor in soybean production. Water requirement of soybean is known to vary with climatic conditions, management practices and length of growing season. Moisture deficiency during vegetative stages of soybean development reduces the rate of plant growth. Yield of soybean is adversely affected by moisture stress during the pod filling period and may result in 20-50% reduction in grain yields (Mavi, 1986). Somerholder and Schlensems (1960) reported that single irrigation applied at the late stage of flowering produced higher yield than when the plant were irrigated at the start of flowering and again at the late flowering stage. Shinde *et al.*, (1987) observed that increase in IW/CPE ratio increased seed yield and water consumption but decreased water use efficiency in sunflower. Water use efficiency of soybean was evaluated under different water regimes using a line source sprinkler technique (Hanks *et al.*, 1976) which facilitates the application of variable water at varying perpendicular distances from the sprinkler line.

A field experiment was conducted on a loamy-sand soil at Ludhiana during June to October 1997. Two cultivars of soybean namely PK-416 and SL-295 were sown on 13th June at row to row spacing of 45 cm and plant to plant spacing of 5cm, using recommended fertilizers. Four variable irrigation treatments (I_4, I_3, I_2 and I_1) were created in the direction perpendicular to sprinkler line and the amount of water applied per treatment was measured in calibrated catch cans. The crop received a pre-sowing irrigation of 50 mm, which was equal and common to all plots to establish the crop stand. Subsequently four irrigations were applied to soybean crop as given below:

A rainfall of 105.2 mm in June, 93.0 mm in July, 409.6 mm in August, 30.4 mm in September and 23.6 mm in October was recorded at the site.

Soil water retention in 0-150 cm root zone was monitored with the neutron probe. Soil water was determined at weekly intervals and in addition immediately before as well as 24 to 48 hours after each irrigation from sowing to maturity of the crop. Water use efficiency for seed and straw yield was calculated.

Total water use during growth season of the crop was obtained by adding depletion of root zone soil moisture between successive sampling dates.

Soil water retention at each sampling was given by

$$\text{Root zone water retention} = \sum_{i=1}^{n} Dj$$

Table 1: Irrigation water applied in four post-sowing irrigations under four moisture regime treatments

Day after Sowing	Cultivar	Irrigation water applied (mm)			
		I_1	I_2	I_3	I_4
22	PK-416	12.1*	24.7	34.6	50.1
	SL-295	14.1	24.9	34.7	49.0
90	PK-416	13.8	22.1	31.3	42.3
	SL 295	15.3	22.1	34.8	45.2
106	PK-416	15.6	24.3	35.7	43.3
	SL 295	14.4	24.8	33.2	48.0
125	PK-416	13.0	20.0	30.5	47.3
	SL 295	13.3	23.4	33.5	47.6

Table 2 : Water use efficiency of soybean cultivars under different water regime treatments

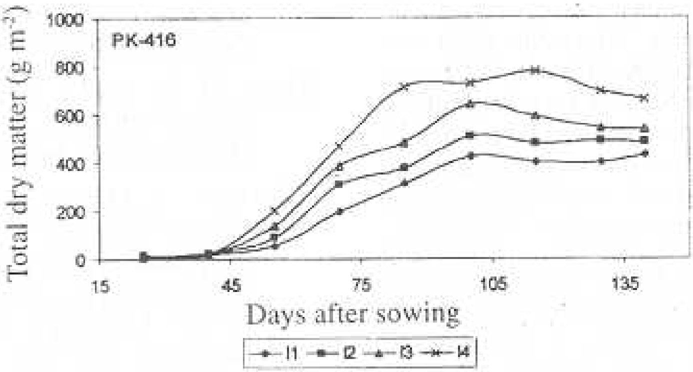
Cultivar and water regimes	Total water use (mm)	Straw yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Water use efficiency kg ha^{-1} mm^{-1}	
				Straw	Seed
PK-416					
I_1	482.6	3642.0	1337.0	7.55	2.77
I_2	515.1	4044.0	1462.0	7.85	2.83
I_3	530.3	4315.0	1512.0	8.13	2.82
I_4	577.9	4550.0	1603.0	7.87	2.77
SL-295					
I_1	491.1	3785.0	1362.0	7.70	2.77
I_2	525.2	4113.0	1493.0	7.90	2.83
I_3	542.1	4500.0	1582.0	8.30	2.91
I_4	595.9	4800.0	1687.0	8.05	2.83

where,

i = soil depth interval (0-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm)

D_i = Depth of water retained in the respective soil depth interval.

It was assumed that no deep drainage (or percolation) occurred below the root zone. Dry matter accumulation was recorded at periodic intervals starting at 25 days after sowing. Stalk dry matter and grain yields were recorded at harvest from a net plot of 8m x 1.8 m. Regression analysis was done between cumulative water use and dry matter accumulation.



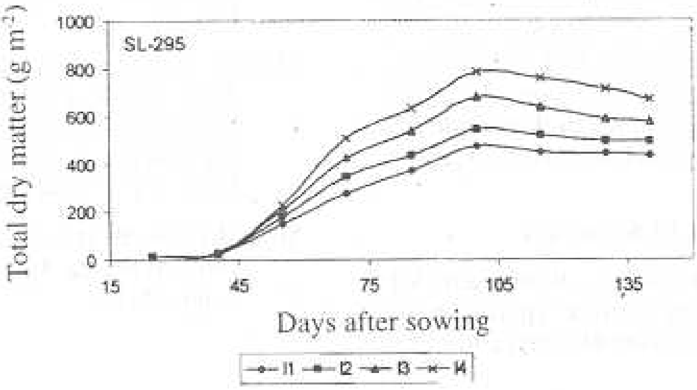


Fig. 1 : Total dry matter production of two soybean cultivars under four irigation treatments

Since the crop was sown after a uniform pre-sowing irrigation, the water storage in the profile was similar at the beginning for all the treatments. The irrigation applied was highest in the I_4 treatment after differential irrigation at 22 days after sowing (DAS) in both cultivars of soybean (Table 1). Higher amount of water received by I_4 and I_3 treatment provided the better growth environment by avoiding moisture stress in the crop. The periodic depletion in soil moisture due to evaporation and transpiration under different water regime treatments indicated that during the growth season of the crop, the total crop water use amounted to 577.9, 530.0, 515.10, 482.6 mm in PK-416 and 596.0 mm, 542.1 mm, 525.2 mm and 491.1 mm in SL-295 for the I_4, I_3, I_2, and I_1 treatments, respectively (Table 2).

The water use efficiency for straw and seed yield was maximum for I_3 and minimum for I_1 treatment in both the cultivars of soybean (Table 2). The results revealed that with increase in water application beyond I_3 level, water use efficiency decreased due to lower efficiency of the crop to utilize excess available water for increasing grain production linearly. Since the water use of 530.10 mm in PK-416 and 542.1 mm (I_3 treatment) in SL-295 gave the highest relative yield and a decline occurred below and above this level, these values represent the optimal seasonal evapotranspiration requirement for these cultivars of soybean.

The dry matter production showed little differences under different water regimes before applying differential irrigation (Fig. 1). From 70 DAS onwards, the increase in dry matter accumulation was rapid up to 100 DAS in both the cultivars, thereafter, it declined. With the start of differential irrigation, dry matter accumulation remained highest under the I_4 and gradually decreased for I_3, I_2 and I_1 treatments.

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